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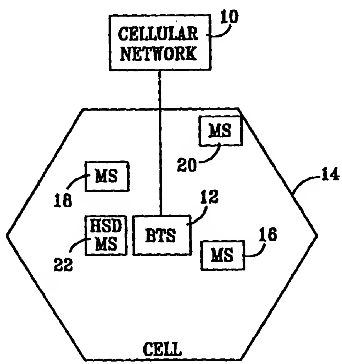
(54) Title: ADAPTIVE MODULATION FOR CDMA SYSTEMS

(57) Abstract

Disclosed is a method of and apparatus for increasing the capacity of a wireless communication system. This is accomplished by having users that can support a higher than base modulation order be required to do so under predetermined conditions such as electrical distance from a base transceiver station (BTS) antenna to a user, the reception of data in a high speed burst (HSD) and the like. The same digital processor apparatus that may be used to provide a base order modulation scheme may be reprogrammed in a more complex fashion to provide signal processing at the higher modulation rate for any given user channel.



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ADAPTIVE MODULATION FOR CDMA SYSTEMS

This Application is a continuation-in-part of and claims the benefit of U.S. Provisional Application Number 60/079,825, filed 30 March 1998.

TECHNICAL FIELD

The present invention relates in general to variable modulation order and in particular to methods and systems for providing a wireless system which adjusts the modulation order of data being transmitted to the various users in a wireless system on an individual user basis.

BACKGROUND

Wireless communication systems have, in recent years, seen a tremendous growth surge. Advances in signal processing, driven by the demand for high speed data as well as improvements in spectral efficiency (such as for voice users), have made the balance between radio capacity and available user channels more complicated. For example, recent standards and equipment modification proposals relating to the use of high speed data (HSD) will further contribute to the problem. Such units will be capable of receive and/or transmit operations on multiple channels such as supplemental channels, a fundamental channels and dedicated control channels simultaneously.

In cellular systems, code channel availability as well as overall system capacity can be increased when cells are made ever smaller (more cells in a given area),however, various issues, including cost, efficiency and interference from transmissions in other cells, prevent such action from being a total solution.

In code division multiple access (CDMA) systems, the number of users that can be accommodated is a function of the available code channels. Typically, CDMA systems use Walsh codes, a set of orthogonal codes, where the number of codes available equals the chip rate divided by the data rate. Channels encoded with Walsh codes are called "Walsh channels" or "code channels." It is desirable to use orthogonal codes in the forward link (FL) since much of the inter-channel interference cancels when orthogonal codes are used. As should be apparent, the FL comprises communication

from the base transceiver station (BTS) to the mobile station (MS).

Typically, spread-spectrum communications systems such as CDMA, employ pseudo-random noise (PN) codes for spreading the communication signal to the desired bandwidth. As is well known in the art, a PN code is comprised of chips where a chip may be equated to a unit of time duration. A PN sequence of chips may be used in CDMA as a scrambling code. Following data modulation via a phase shift keyed output signal of a given modulation order, prior art CDMA, PCS and cellular communication systems, added Walsh codes and PN spreading combined in a well known manner. Known systems have used binary phase shift keyed (BPSK) and quadrature phase shift keyed (QPSK) modulation orders.

In general there are N orthogonal codes for a code of length N bits (chips). This also applies to Walsh codes, wherein there are N length N orthogonal Walsh codes. It may be noted that the PN chip rate is the same as the Walsh chip rate. In order to have consistent numerology the PN chip rate must equal the modulation symbol rate times the Walsh code length in chips.

In the design of some prior art systems using QPSK, a data rate into the encoder of 9,600 symbols per second, and a PN chip rate of 1.2288 Mcps (mega chips per second) allowed for 128 code channels to be transmitted simultaneously from a BTS antenna when the radio environment supports that many users (or user channels).

PCS and cellular communications systems often encounter various types of radio environments. For example, the radio signal may encounter various degrees of fading due to multipath and mobile velocities. Other factors such as shadowing may also cause a reduction of signal strength between transmitter and receiver. These same obstacles may also cause signal reflection which results in multipath signals that tend to confuse the receiver in determining what signal to detect. Some of these problems may be overcome by increasing the power of the transmitted signal. In view of the above, the radio environment may be such that the BTS (forward link) runs out of transmitter power before the number of code channels (Walsh codes) available are exhausted. It is generally deemed desirable for the radio environment to limit the system capacity rather than the number of available code channels. However, there may be situations in a given system when the available Walsh channels are exhausted before the BTS power limit is reached. In this case the capacity of the system is artificially limited by the Walsh code channels rather than the radio environment.

BPSK (modulation order of 2) systems are simpler to implement than are QPSK systems since the signal processing complexity is greater for the latter. While an 8 or other higher order system might immediately come to ones mind as a way to solve the problem of having an adequate number of Walsh codes, other considerations must be addressed. If the transmissions employ higher order modularity ($M > 4$), then all users must purchase new equipment to use the system. Further, the transmissions must remain orthogonal in order for the system to be usable and/or

practical, numerology must be accommodated and so must FEC coding. Just because BPSK and QPSK systems proved to be capable of providing orthogonality, does not mean that higher order modulation schemes are also orthogonal. With proper design, the result of which will be revealed below, these considerations can be satisfied. Therefore, it would be desirable to use a higher modulation order system when both the radio environment and the mobile capability can support a higher modulation order.

SUMMARY OF THE INVENTION

The present invention comprises providing a wireless system, such as CDMA, which uses a base modulation order such as QPSK when the system user capacity is adequate and using a higher order modulation scheme for selected users when code channels are limited.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and its advantages, reference will now be made in the following Detailed Description to the accompanying drawings, in which:

FIGURE 1 is a simplified diagram of a cellular system;

FIGURE 2 is a block diagram illustrating how Walsh codes and PN spreading are typically combined with incoming data in a CDMA system;

FIGURE 3 provides more detail for a portion of FIGURE 2 when QPSK modulation is used;

FIGURE 4 illustrates one approach to performing 8-PSK modulation while using the data input of the 4-PSK of FIGURE 3 and utilizing longer Walsh codes, with respect to those used for 4-PSK, for a given data rate;

FIGURE 5 illustrates a second approach to performing 8-PSK modulation while using the data input of FIGURE 3 (corresponding to 4-PSK) and utilizing longer Walsh codes, with respect to those used for 4-PSK, for a given data rate;

FIGURE 6 illustrates a third approach to performing 8-PSK modulation while using the data input of FIGURE 3 (corresponding to 4-PSK)and utilizing longer Walsh codes, with respect to those used for 4-PSK, for a given data rate; and

FIGURE 7 illustrates a fourth approach to performing 8-PSK modulation while utilizing longer Walsh codes, with respect to those used for 4-PSK, for a given data rate.

DETAILED DESCRIPTION

In FIGURE 1, a cellular network, represented by block 10, communicates with a BTS 12. In general, a BTS may also communicate with MSs in neighboring cells. The BTS 12 transmits signals to various MSs within a defined distance as represented by the outlines of a cell 14. The BTS 12 transmits these signals via an antenna not shown. Within cell 14 are shown MSs 16, 18 and 20 with MS 16 being physically and electrically close to the BTS 12. It is common knowledge that a user can be physically close to a BTS antenna and still not have a "good", strong and/or clear signal. Thus further references to the distance between an MS and a transmitting antenna of a BTS such as 12 will by definition refer to "close" as having a strong and easily detectable signal when a small amount of power is used to transmit signals to that MS. In the alternative, an MS is "far" from an antenna when the signal received by the MS is weak in strength and/or hard to accurately detect even though a relatively large amount of power is used to transmit signals to that MS. In other words, many different factors such as terrain, atmospheric conditions, buildings and so forth could result in MS 18, for example, being electrically farther away than MS 20 which is physically located near the extreme edge of cell 14. An additional MS 22 is shown, where MS 22 is capable of receiving and/or transmitting HSD.

In FIGURE 2, payload data is input to a Cyclic Redundancy Check (CRC) block 30 which adds to the total data transmitted. Additional data bits are inserted by a tail block 32. In one prior art system, the data rate at the output of block 32 was 9600 bps (bits per second). The output of block 32 is applied

to a forward error correction (FEC) circuit block 34. For example, when code rate (R) is ½ (1/N = ½), the output of block 34 is applied at a rate of 19,200 bps to a block interleaver 36 which performs a reordering of the bits comprising each frame of data passing through the block. The output of block 36 remains at the 19,200 bps rate and is applied to an inphase and quadrature phase (I/Q) mapping block 38 where 2 bits of data at a time are used to define in-phase and quad-phase output signals on leads 40 and 42 respectively. These outputs occur at a 9600 sps (symbols per second). The leads 40 and 42 are connected respectively to combining or multiplying means 44 and 46 respectively. A Walsh code is supplied on a lead 48 to a second input of each of the means 44 and 46. The outputs of the multipliers 44 and 46 are supplied to a PN spreading block 50, which has in- and quad- phase outputs on leads 52 and 54 respectively.

FIGURE 3 repeats a portion of FIGURE 2 and shows blocks 34 through 46 utilizing the same designators. FIGURE 3 illustrates in addition that as the bit rate into the encoder is increased, the Walsh code length and accordingly the number of user channels that can be accommodated with a system decreases.

FIGURE 4 shows a single user channel having identical bit rate inputs as presented in FIGURE 3 while employing a higher order modulation in order to increase the Walsh code lengths, as compared to FIGURE 3, and thus increase the number of user channels available in the system. The approach presented in this figure, and the following FIGURES 5 and 6, is unique and was originated to utilize the same bit rate

as presently used in the prior art. In the following explanation, the input will be assumed to be 9.6 kilo bits per second (kbps). The example of FIGURE 4 shows 8-PSK but similar techniques would allow the use of even higher order modulation, for example, 16-PSK or 16-QAM, or higher. An encoder 60, having a code rate of 2/3, in contrast to the code rate 1/3 as in FIGURE 3, passes its 14.4 kbps output signal to a puncture block 62, where a selected one of each 4 bits is removed before passing the resulting 10.2 kbps bit stream to an 8-PSK mapping block 64. The 8 PSK mapping uses 3 bits per symbol to provide an output of only 3.6 ksps (kilo symbols per second). The blocks 60, 62 and 64 are enclosed with a dash line to indicate the TCM Encoder portion of this circuitry where TCM is an acronym for Trellis Coded Modulation. In order to get the rate up to an amount necessary to obtain the proper Walsh code, each symbol is duplicated in a symbol repetition block 68 to obtain a symbol rate of 7.2 ksps. It is noted that the symbol repetition is optional. Alternately, if the symbols are not repeated then the Walsh code lengths can be doubled for each of the respective data rates. Of course, the longer Walsh code lengths support more user channels, however, there are other considerations which might impact this choice. For example, due to the coherence time of the channel, a shorter or longer Walsh code may be desired. A symbol block interleaver 70 then interleaves the symbols, followed by Walsh coding via multipliers 72 and 74. A simple mathematical examination will prove that this process allows at least twice the number of user channels for a given payload data input rate as obtained with 4-PSK (QPSK). Note that without the symbol repetition, block 70, four times the user channels are allowed. _It may

also be shown, either by testing or mathematics, that the summation of all the channels are orthogonal and provide the desired cancellation effect.

For QPSK, such as set forth in FIGURE 3, the quadrature bit stream (i.e., in-phase and quadrature channels), is equivalent to two BPSK bit streams, one on the in-phase and one on the quadrature channel. Thus, in such a case, at the receiver, inverse mapping, with respect to the I/Q mapping shown in FIGURE 3, is employed followed by decoding of the FEC encoded data stream. In contrast, however, for higher modulation orders (i.e., $M > 4$), the inverse of I/Q mapping is not as straight forward with respect to optimal detection of the FEC code. Therefore, the channel coding and modulation are combined (as is well understood in the art), whereby a Trellis code is employed at the transmitter, as shown in FIGURE 4.

It is noted that a rate $n/(n+1)$ (e.g., rate 2/3) Trellis code is readily available in the literature. In the subsequent description, various methods are identified for obtaining a desired code rate for the trellis codes, other than $R = n/(n+1)$, which is compatible with the present invention. The optimal method for rate matching of the TCM encoding, however, will be a function of the Trellis Code design and thus the preferred method among those methods described herein (i.e., Figures 4 - 7) should be chosen accordingly. The rate matching methods described herein are symbol repetition, bit repetition, and puncturing. Puncturing is a method by which $1/m$ (m a positive integer larger than zero) bits or symbols are removed from the information stream in a prescribed fashion. For example, suppose the bit rate into an FEC

block is n/(n+1), repetition of each bit (original plus one copy), followed by puncturing 1 of m bits. Then, the bit rate following the puncturing is given by

$$2 \cdot \frac{1}{R} \cdot \frac{m-1}{m} .$$

In contrast, a code rate R = 1/n FEC code for BPSK or QPSK modulation (M ≤ 4) are readily available, as well as puncturing patterns.

In FIGURE 5, an encoder 80, a bit repetition block 82, a puncture block 84, and an 8-PSK mapping block 86 form a TCM encoder 88. In this figure, the bits, prior to puncturing, are repeated rather than the symbols such that the output bit rate of block 82, assuming a bit rate into encoder 80 is 9.6 Kbps, is 28.8 Kbps. Removing 1/4 of these bits results in a bit rate of 21.6 ksps at the input of block 86. In block 86, combining 3 bits per symbol produces the indicated output symbol rate of 7.2 Ksps. A block 90 and the associated multipliers 92 and 94 perform in the same manner as shown in FIGURE 4.

In FIGURE 6, an encoder 100, a puncture block 102 and an 8-PSK mapping block 104 comprise the TCM encoder 106. Since the code rate in block 100 is 1/3, the output of the encoder 100 is already at 28.8 kbps and thus repetition is not required (i.e., to get the correct bit rate to block 104), as occurred in FIGURE 5. A block interleaver 108 and multipliers 110 and 112 operate as did similar blocks in FIGURE 5. It may be noted that Figure 6 is based on a 1/3 rate FEC code, so therefore, the resulting TCM code may require development beyond that which is available in the current literature. If such development is required,

it is believed straightforward for those skilled in the art along the lines of established mathematical methods.

In FIGURE 7, an encoder 120 and an 8-PSK mapping block 122 form a TCM encoder 106. In this figure, no puncturing is required since the code rate in block 120 is 2/3 and thus its output is 21.6 kbps with an input bit rate of 14.4 kbps. In block 122, combining 3 bits per symbol produces the indicated output symbol rate of 7.2 Ksps. An interleaver block 126 and its associated multipliers 128 and 130 perform in the same manner as shown in FIGURE 5. Although the bit rate input shown in FIGURE 7 varies from that presently used in QPSK CDMA systems, this approach has definite advantages in not requiring the puncturing of FIGURES 4-6 or the repetition action of FIGURES 4 and 5. FIGURE 7 further uses presently available technology in that encoder 120 uses R=2/3. Finally, the straightforward architecture of FIGURE 7 is able to accommodate a given number of codes with a higher input data rate than occurs in FIGURES 4-6. It should be noted that a single digital processor chip may be programmed or configured to perform the functions required by the circuitry blocks shown in each of the FIGURES 3, 4, 5, 6 and 7. In other words, a digital processor may be programmed (or reprogrammed) to create either a base modulation order such as BPSK, 4-PSK or a higher modulation order such as 8 or 16 and provide the required orthogonal output.

With the above in mind, it should be apparent that a wireless network can be designed such that any given user channel may operate at either some system base modulation rate such as QPSK or at a higher

modulation order. For example, the BTS unit may output several channels, where each of the individual code channels employ any of the aforementioned modulation orders, while all the code channels still maintain orthogonality with respect to one another. This alternate operational mode may be obtained, when circumstances require and/or the radio environment permits, by reprogramming the appropriate digital processor performing the function illustrated in any of the FIGURES 3-7.

A BTS has data available to the BTS as to how close electrically any given MS is to an antenna. For example, the power transmitted to an MS in a CDMA system may be adjusted to a level necessary to obtain good reception by a MS in accordance with data (or some indicator) returned to the BTS from the MS. This tends to optimize the system for power radiated by a BTS antenna as well as helping minimize interference between user channels. For example, depending on the complexity of the Trellis codes (i.e., complexity with respect to TCM code states), if the power required in supplying signals to a given MS is low compared to other MSs, it should be a good candidate for receiving signals using a higher modulation order. Such a determination is even more important when a given MS is provided data in the form of a high data rate since a large number of channels may be required for such an action.

While it is believed that the use of a higher order modulation for even some of the MS users in a system will allow more user channels to be active, some numerical examples will be set forth.

It may be assumed that a HSD user in a single order 4-PSK system such as presented in FIGURE 3 is assigned a Walsh code length of 4 where the base Walsh length is 256 as shown in the first line of FIGURE 3. Although the user communicates at a very high rate, that single user consumes 1/4 of the total Walsh codes. In such a situation, the system supports 1 HSD user + 3/4 of 256 other code channels for a total of 193 users (for the purpose of this explanation, a code channel is equated to a user).

If this HSD user operates in a system as set forth in the present invention where one or more channels may employ a higher modulation order than a base modulation order, then significantly more users may be accommodated. It may be assumed that the HSD user is electrically close enough to the BTS that the user may readily support a modulation order of 8 based on a Walsh length of 512. For a given total data rate, a Walsh length of 8 in such a system is equivalent to a Walsh length of 4 when the modulation order is 4. Thus a HSD user that can support 8-PSK would only consume 1/8 of the total 512 codes available. It may be noted that a "normal" (base modulation order - QPSK) user, effectively uses two 512 codes. Based upon the above description this system may support 1 HSD user +7/8 (512/2) for a total of 1 + 224 or 225 users. This increases the code channels by 32, where the only user of the higher modulation order is a single HSD unit.

Some of the regular users may also support a higher order transmission rate. It should thus be apparent that the maximum number of available orthogonal code channels can be significantly

increased over that obtainable from prior art systems that supported only a single modulation order.

The present invention has been described primarily with respect to CDMA using 4-PSK as a base modulation order and 8-PSK as an alternate modulation order for some or all of the channels when the radio environment supports the higher modulation order. However the invention is believed to cover all wireless systems which may use different modulation orders in accordance with various factors including but not limited to the radio environment.

Although the invention has been described with reference to specific embodiments, these descriptions are not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as alternative embodiments of the invention, will become apparent to persons skilled in the art upon reference to the description of the invention. It is therefore, contemplated that the claims will cover any such modifications or embodiments that fall within the true scope and spirit of the invention.

WHAT IS CLAIMED IS:

1. A method for increasing throughput in a CDMA network, comprising the steps of:

determining if a user can support communication at a higher modulation rate; and

communicating with the user at the higher modulation rate.

2. The method of Claim 1 wherein the higher modulation rate consists of QPSK modulation.

3. The method of Claim 1 wherein the higher modulation rate consists of 8-PSK.

4. The method of Claim 1 wherein the higher modulation rate comprises any M>4 modulation order.

5. Cellular transmitter apparatus in a CDMA network, comprising:

means to communicate with a first modulation scheme;

means to communicate with a second modulation scheme; and

logic circuitry for selecting between the first and the second communication schemes.

6. A method for increasing throughput in a CDMA network, comprising the steps of:

normally using a base modulation rate for all users communicating with a given base station;

determining, under predetermined conditions, if given users can support communication at a higher modulation rate than said base modulation rate; and

communicating with at least some of said given users the higher modulation rate.

7. The method of claim 6 wherein the predetermined conditions comprises a given percentage of total radio and or code capacity is being used.

8. The method of claim 6 wherein the predetermined conditions comprises requiring HSD users to operate at a higher modulation rate than the base rate.

9. The method of claim 6 wherein the predetermined conditions comprises requiring users electrically closest to a communicating antenna to operate at a higher modulation rate than the base rate.

10. A method for increasing throughput in a wireless network, comprising the steps of:

establishing a base modulation rate for all users communicating with a given base station; and

requiring users electrically closest to said given base station, who can support communication at a higher modulation rate than said base modulation rate, to use a higher modulation rate than users electrically farther away from said given base station.

11. A method for increasing throughput in a CDMA network, comprising the steps of:

establishing a base modulation order for all users communicating with a given base station; and

requiring users wanting to send high speed data to do so at a higher modulation order than said base modulation order.

12. A method for increasing throughput in a wireless network, comprising the steps of:

determining if a user MS can support communication at a given higher modulation order; and

communicating with the MS using said given higher modulation order.

13. Cellular transmitter apparatus in a wireless network, comprising:

means to communicate with a first modulation scheme;

means to communicate with a second modulation scheme; and

logic circuitry for selecting between the first and the second communication schemes.

14. Performing trellis code modulation comprising the steps of:

n/(n+1) encoding an incoming signal to provide a second signal;

puncturing by removing 1 of each set of n bits of said second signal to produce a third signal;

in phase and quad phase mapping said third signal to provide fourth and fifth signals as outputs.

15. Performing trellis code modulation comprising the steps of:

n/(n+1) encoding an incoming signal to provide a second signal;

repeating the bits of said second signal to produce a third signal;

removing 1 of each set of n bits of said third signal to produce a fourth signal;

in phase and quad phase mapping said fourth signal to provide fifth and sixth signals as outputs.

16. Performing trellis code modulation comprising the steps of:

1/n encoding an incoming signal to provide a second signal;

removing 1 of each set of m bits of said second signal to produce a third signal;

in phase and quad phase mapping said third signal to provide fourth and fifth signals as outputs.

17. Trellis code modulation apparatus comprising:

a n/(n+1) encoder;

puncture means for removing bits for an output signal of said n/(n+1) encoder in accordance with a predetermined function; and

in phase and quad phase mapping means for mapping signals output by said puncture means.

18. Trellis code modulation apparatus comprising:

a n/(n+1) encoder;

bit repeating means for duplicating each bit output by said n/(n+1) encoder;

puncture means for removing bits for an output signal of said bit repeating means in accordance with a predetermined function; and

in phase and quad phase mapping apparatus for mapping signals output by said puncture means.

19. Trellis code modulation apparatus comprising:

a 1/n encoder;

puncture means for removing bits for an output signal of said 1/n encoder in accordance with a predetermined function; and

in phase and quad phase mapping means for mapping signals output by said puncture means.

20. Modulation apparatus comprising:

a n/(n+1) encoder;

puncture means for removing bits for an output signal of said n/(n+1) encoder in accordance with a predetermined function;

in phase and quad phase mapping means for mapping signals output by said puncture means;

symbol repetition means for duplicating the symbols output by said in phase and quad phase mapping means;

block interleaver means for reordering in phase and quad phase symbols output by said symbol repetition means; and

combining means for altering the output of said block interleaver means to a given Walsh code.

21. The method of claim 14 wherein n=2 and m=4.

22. The method of claim 15 wherein n=2 and m=4.

23. The method of claim 17 wherein n=2.

24. The method of claim 18 wherein n=2.

25. The method of claim 20 wherein n=2.

26. The method of claim 16 wherein n=3.

27. The method of claim 19 wherein n=3.

FIG. 1

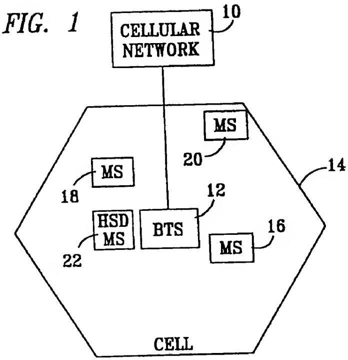
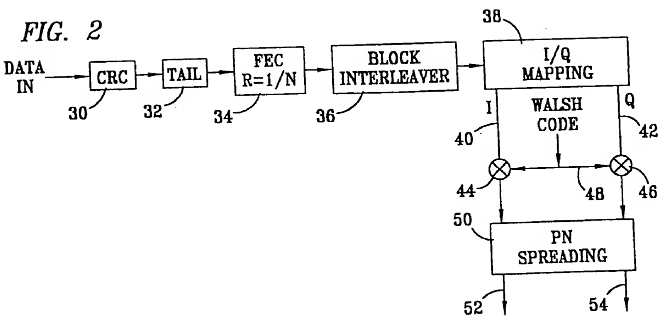

10
CELLULAR NETWORK
MS
20
14
MS
18
12
HSD MS
BTS
16
MS
22
CELL

FIG. 2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CRC
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TAIL
32
FEC R=1/N
34
BLOCK INTERLEAVER
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I/Q MAPPING
I
WALSH CODE
Q
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48
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50
PN SPREADING
52
54

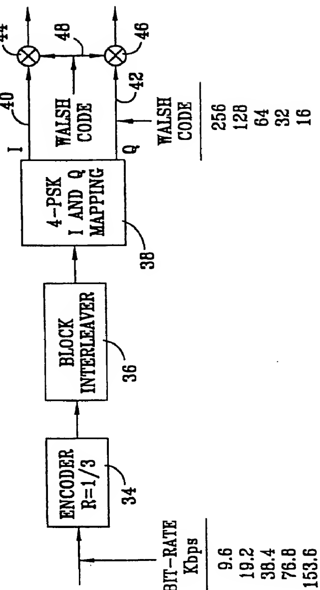

ENCODER
R=1/3
34
BLOCK
INTERLEAVER
36
4-PSK
I AND Q
MAPPING
38
I
40
Q
42
WALSH
CODE
44
48
46
BIT-RATE
Kbps
9.6
19.2
38.4
76.8
153.6
WALSH
CODE
256
128
64
32
16

FIG. 3

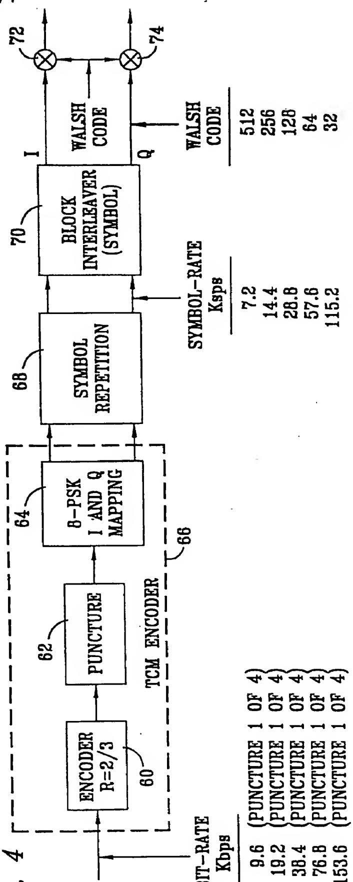

ENCODER
R=2/3
60
PUNCTURE
62
8-PSK
I AND Q
MAPPING
64
TCM ENCODER
66
SYMBOL
REPETITION
68
BLOCK
INTERLEAVER
(SYMBOL)
70
I
Q
WALSH
CODE
72
74
BIT-RATE
Kbps
9.6 (PUNCTURE 1 OF 4)
19.2 (PUNCTURE 1 OF 4)
38.4 (PUNCTURE 1 OF 4)
76.8 (PUNCTURE 1 OF 4)
153.6 (PUNCTURE 1 OF 4)
SYMBOL-RATE
Ksps
7.2
14.4
28.8
57.6
115.2
WALSH
CODE
512
256
128
64
32

FIG. 4

FIG. 5

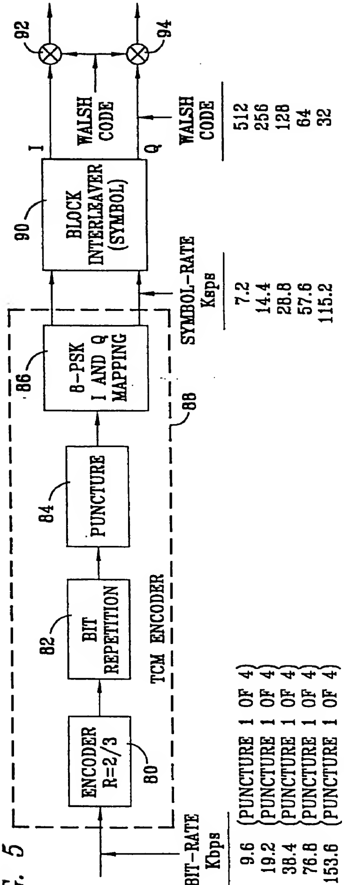
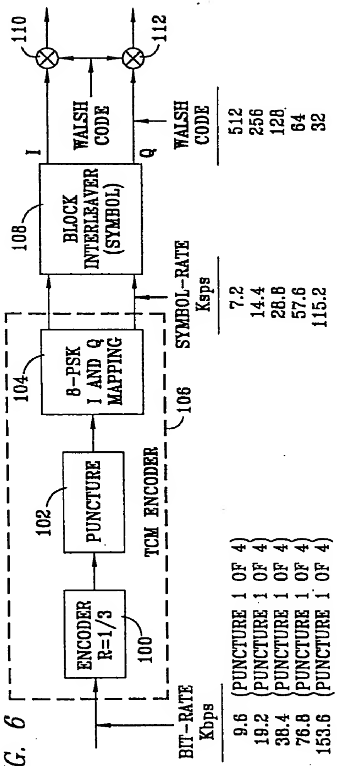

ENCODER R=2/3
80
BIT REPETITION
82
PUNCTURE
84
8-PSK I AND Q MAPPING
86
TCM ENCODER
88
BLOCK INTERLEAVER (SYMBOL)
90
I
Q
WALSH CODE
92
94
BIT-RATE Kbps
9.6 (PUNCTURE 1 OF 4)
19.2 (PUNCTURE 1 OF 4)
38.4 (PUNCTURE 1 OF 4)
76.8 (PUNCTURE 1 OF 4)
153.6 (PUNCTURE 1 OF 4)
SYMBOL-RATE Ksps
7.2
14.4
28.8
57.6
115.2
WALSH CODE
512
256
128
64
32

FIG. 6


ENCODER R=1/3
100
PUNCTURE
102
8-PSK I AND Q MAPPING
104
TCM ENCODER
106
BLOCK INTERLEAVER (SYMBOL)
108
I
Q
WALSH CODE
110
112
BIT-RATE Kbps
9.6 (PUNCTURE 1 OF 4)
19.2 (PUNCTURE 1 OF 4)
38.4 (PUNCTURE 1 OF 4)
76.8 (PUNCTURE 1 OF 4)
153.6 (PUNCTURE 1 OF 4)
SYMBOL-RATE Ksps
7.2
14.4
28.8
57.6
115.2
WALSH CODE
512
256
128
64
32

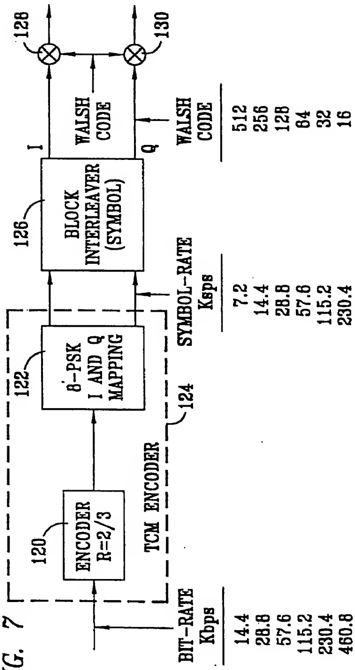

ENCODER
R=2/3
120
8-PSK
I AND Q
MAPPING
122
TCM ENCODER
124
BLOCK
INTERLEAVER
(SYMBOL)
126
I
Q
WALSH
CODE
128
130
BIT-RATE
Kbps
14.4
28.8
57.6
115.2
230.4
460.8
SYMBOL-RATE
Ksps
7.2
14.4
28.8
57.6
115.2
230.4
WALSH
CODE
512
256
128
64
32
16

FIG. 7